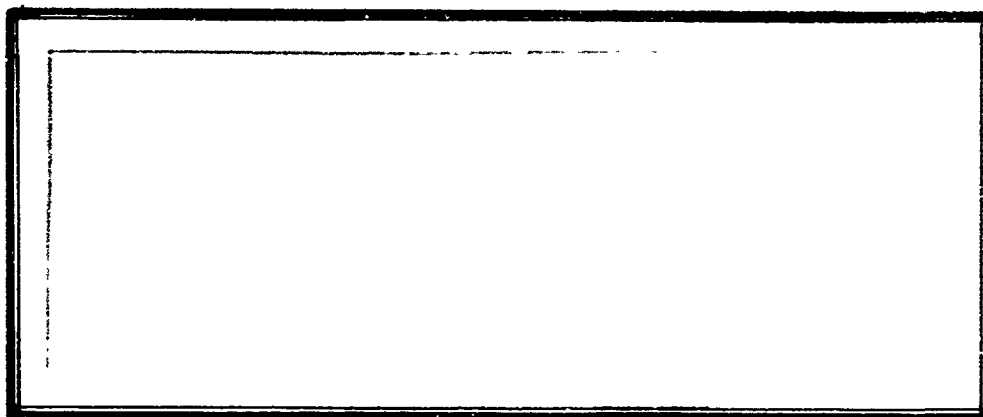


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U. S. NAVAL MEDICAL RESEARCH LABORATORY

U. S. Naval Submarine Base

New London, Connecticut

MEMORANDUM REPORT 60-2

Recommendations for
Minimal Red Light Levels on Board Submarines

MR005.14-1100.01.06

14 January 1960

Principal Investigator:

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Approved by:

Walter R. Miles, Ph.D.
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Released by:

Geo. F. Bond, CDR MC USN
Officer-in-Charge

SUMMARY PAGE

THE PROBLEM:

To determine specific limiting brightness values for light sources and working surfaces for submarine compartments where red lighting is required, in order to provide adequate seeing conditions under red light with minimum interference to dark-adapted personnel.

FINDINGS:

Since acuity decreases as the level of illumination is lowered, whereas dark adaptation increases, any specifications of brightness levels can be no more than a workable compromise between the two requirements. Accordingly, initial adaptation should be made under the best possible conditions, that is under the lowest feasible red illumination wherein the men can perform necessary tasks. —

APPLICATIONS:

The findings of this investigation have immediate application to the red lighting practices in operating submarines.

ADMINISTRATIVE INFORMATION

This investigation was undertaken as a part of the Bureau of Medicine and Surgery's Task 1100 - Human Engineering in Shipboard and Submarine Operation, Subtask - 1 Submarine Photometric Surveys. The present report is No. 6 on this subtask and was approved for publication on 14 January 1960.

Published by the Naval Medical Research Laboratory

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~~(Released as of 16 February 1960)~~

RECOMMENDATIONS FOR
MINIMAL RED LIGHT LEVELS ON BOARD SUBMARINES

DATA REQUESTED:

Determination of specifications for shipboard low level red illumination.

REQUESTED BY:

BuShips ltr S64-1(660W) Ser 650-53398 of 16 July 1958

This request states, "In order for the Bureau to formulate uniform specifications for shipboard low level illumination, it is considered necessary to determine specific limiting brightness values for light sources and working surfaces in those compartments where red lighting is required." It is further pointed out, "This survey should be based on providing adequate seeing conditions under red light with minimum interference to dark adapted personnel..."

Responsibility for complying with this request was assigned to the Vision Branch in March 1959.

ANALYSIS OF THE
PROBLEM:

As recognized in the BuShips request, the primary function of illumination is to provide the necessary visual acuity for the performance of essential visual tasks. Experimental studies have furnished considerable information concerning all important visual tasks on board a submarine, and steps have been taken to provide the necessary and sufficient levels of illumination to carry on such tasks with maximum efficiency and adequate visual comfort. At the same time, an attempt has been made to provide the necessary conditions for dark adaptation that are required at certain times of particular personnel. Red light does not, of itself, produce dark adaptation, but is known to interfere least with sensitivity under conditions of night vision, and to expedite dark adaptation in preparation for the performance of night visual tasks. Since acuity decreases as the level of illumination is lowered, whereas dark adaptation increases, resulting specifications can be no more than a compromise between the two requirements. Certain facts concerning the relation of red to white illumination as applied to the submarine situation were not clearly evident in the available literature

and required experimental investigation. These questions were: (a) What relation exists between acuity under red and under white illumination and to what extent may results of acuity studies done under white illumination be applied to the red lighted situation? (b) To what extent are the facts concerning night visual sensitivity following red adaptation applicable to acuity problems under comparable situations? Experimental study of these two problems was undertaken.

RECOMMENDATIONS:

As shown in Ref. 1, acuity, measured by resolution of checkerboard targets at brightness levels from 0.34 to 11.2 ft-L, is substantially the same under both white and red illumination. This finding permits the direct application of acuity measurements and requirements on board submarines to the red lighted situation and the use of acuity studies under white illumination to determine permissible levels of red illumination. The survey of acuity tasks aboard a fleet type submarine (Ref. 2), taking into account the size of target, viewing distances, contrast of detail, and illumination, revealed the most critical visual task to require an acuity of .5 in terms of reciprocal visual angle, which is equivalent to 20/40. Findings of the original survey were extended, at a later date, to include visual tasks for submarine officers. No essential differences were found. A supplementary survey of a modern type submarine was carried out and revealed no essential changes in visual tasks from those reported in the original study (Ref. 3).

A study of the effect of illumination on visual acuity (Ref. 4) shows, in Fig. 1, that the visual acuity of a normal subject (plano) drops to .5 (Snellen equivalent of 20/40) when the illumination is reduced to .15 ft-c, and the acuity of subjects with less than normal vision falls to correspondingly lower acuity levels. In view of the fact that the acuity acceptance requirements for submarine personnel have been recommended to be reduced to 20/60 (Ref. 3), a safety factor must be introduced into the requirements for minimum illumination. It was determined from the data in the referenced study that such a safety factor is accomplished by setting the minimum light level at 0.6 ft-c. This setting provides adequate visibility of critical target to personnel with less than normal vision.

The question of the advantage in preparing for night vision tasks under red illumination has been answered in the affirmative. The same levels of acuity are reached more quickly if the initial adaptation has been to red, than if it has been to white. The times gained for acuity

are of the order of 2-3 minutes as shown in Fig. 2, (Ref. 5), compared with 4-5 minutes in sensitivity studies (Ref. 6). This means that other sensitivity studies may be interpreted to apply to acuity problems with a comparable transformation factor.

The light levels at which the acuity measurements are made have little effect on the differential between white and red initial adaptation. This means that initial adaptation should be made under the best possible conditions, that is, under the lowest feasible red illumination, no matter what the brightness level of the acuity task may turn out to be. This simplifies installations and procedures for dark adaptation.

REFERENCES

1. S. M. Luria and Ira Schwartz, "Visual Acuity under Red and White Illumination," NMRL Report No. 326, Jan 1960
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4. C. Pratt and F. L. Dimmick, "An Ophthalmological Study of Visual Acuity under Dim Illumination," NMRL Report No. 173, June 1951
5. S. M. Luria and Ira Schwartz, "The Temporal Course of Scotopic Acuity as a Function of Red vs. White Initial Adaptation and the Level of Target Illumination," Submitted to J. Opt. Soc. Am., Dec 1959
6. M. S. Katz, A. Morris and F. L. Dimmick, "Effect of Various Durations of Red Adaptation on the Course of Subsequent Dark Adaptation," NMRL Report No. 246, Apr 1954

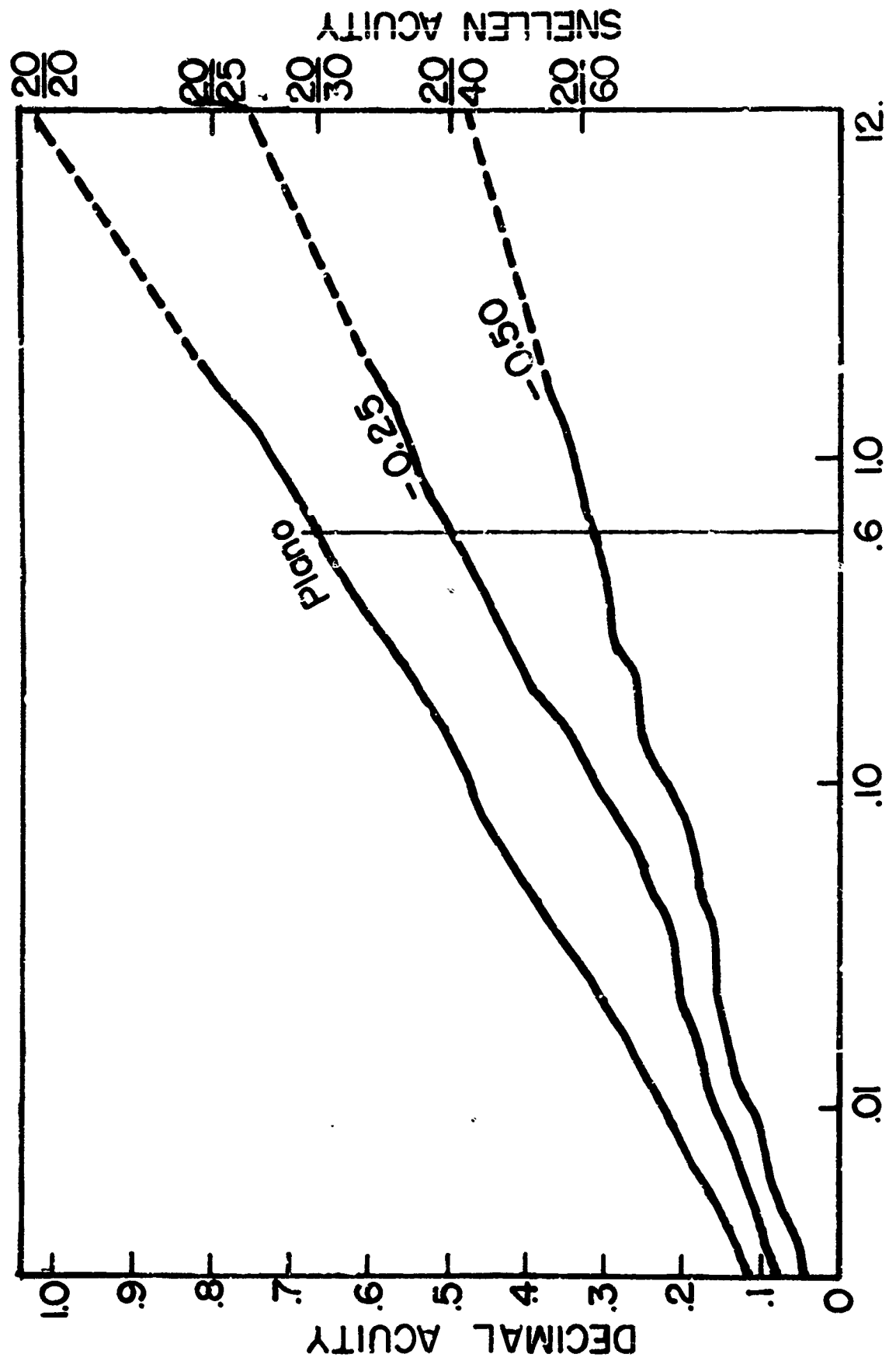


Fig.1- The Effect of Light Level on Acuity

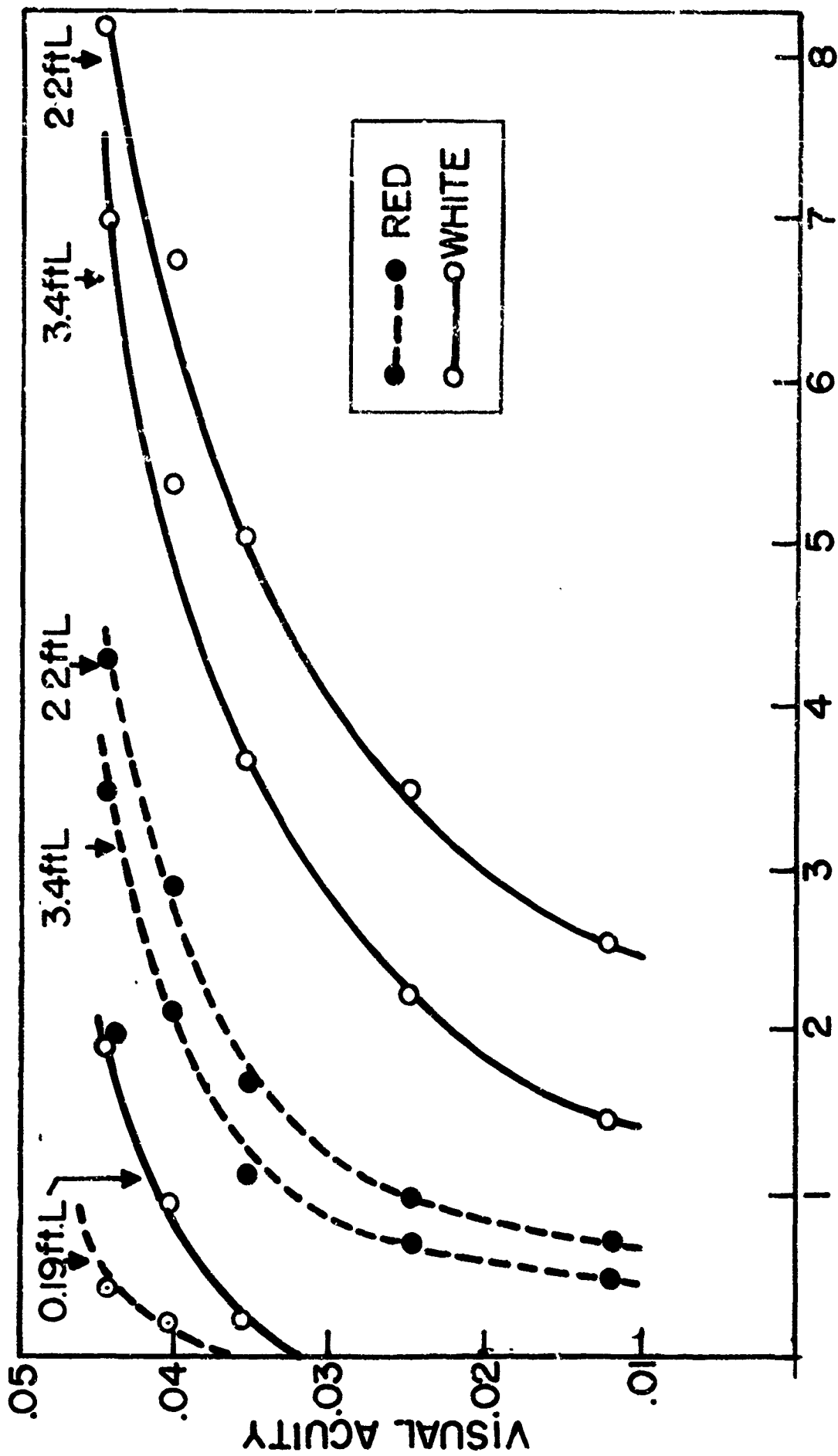


Fig 2— The Advantage of Red over White Initial Adaptation at 3 Light Levels